Amendments to the Drawings:

The attached sheet of drawings includes changes to Figure 1. The legend "Prior Art" has been added to Figure 1.

Attachments: Replacement sheet of Fig. 1
Annotated sheet showing changes to Fig. 1

REMARKS

The Amendments

Claims 1-3 have been cancelled and claims 4 and 5 have been substituted in lieu thereof. The new claims particularly point out and distinctly claim the subject matter Applicants regard as the invention. The new claims are supported by the original claims and throughout the specification. In particular, claim 4 is supported by claims 1 and 2 as filed and by the specification at page 1, lines 13-19; page 6, line 9 to page 7, line 3; and page 8, lines 6-27 of the specification. Claim 5 is supported in particular by original claim 1. Applicants respectfully submit that this amendment adds no new matter to the specification and earnestly solicits favorable action thereon.

Drawing Fig. 1 has been amended to include the phrase "Prior Art" to properly identify this figure as prior art, as described at page 3, lines 12-13. A substitute drawing figure and a copy of the original drawing annotated to illustrate the addition of "Prior Art" (and re-positioning of the "Fig. 1" legend) is filed herewith. Applicants respectfully submit that this amendment adds no new matter to the application and earnestly solicit favorable action thereon.

The Office Action

Claims 1-3 were pending. All claims stand rejected under 35 U.S.C. § 112, first paragraph, for not complying with the enablement requirement. The office action asserts that the claims are directed to subject matter that is not described in the specification in a way that

enables a skilled practitioner to make and use the invention because the specification is said to disclose how to measure only a single nuclide, whereas the claims are directed to measuring many nuclides. Further, the identified patents disclose that gamma-rays emitted by different nuclides are likely to be at the same or very similar energies. Methods of correcting for foreseeable errors also is said not to be disclosed. Therefore, the Office Action asserts that there is no adequate disclosure of how and in what manner the invention is able to determine which two gamma-rays, of all the rays emitted by a sample, are emitted from one nuclide. The failure to disclose how to make this identification is said to place an undue burden on the skilled practitioner.

The office action also asserts that the specification suggests (at the places identified at the second line of page 4 of the Office Action) that various analyses and computations are being carried out, but that the algorithms, formulas, and the like are not disclosed.

In the last complete paragraph on page 4, the office action asserts that the quantification of 49 elements described at page 13 of the specification is not adequately described at least because each element has plural isotopes. Therefore, the office action asserts that the manner by which each of the elements was identified is not disclosed adequately. Further, the office action asserts that the disclosure in the first full paragraph of page 14 is another example of the invention.

The Office Action asserts that the specification does not disclose the energy level required for the neutrons or gamma-rays used to bombard the sample under consideration.

Therefore, the office action asserts that the disclosure is insufficient and non-enabling on this point, and that it would be an undue burden for the skilled practitioner to determine the energy level required to give the desired result with each of the many nuclides in the sample.

The claims also are rejected under 35 U.S.C. § 112, first paragraph, because the best mode contemplated by the inventors at the time the application was filed is said not to have been disclosed. The Office Action asserts that pages 12 *et seq* of the invention that the specification does not disclose algorithms and formulas that were used to detect, for example, the 49 elements in Example 1 or the 23 components of the prior art method summarized there, and that this non-disclosure rises to the level of a failure to disclose the best mode of making and using the invention.

The claims stand rejected under 35 U.S.C. § 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter Applicants regard as the invention, and as omitting steps. In particular, the Office Action asserts that it is impossible to perform the claimed method without being able to simultaneously measure all gamma-rays emitted and to determine which two gamma-rays came from which specific nuclide.

All claims stand rejected under 35 U.S.C. § 102(b) as anticipated by any one of Cole, Schultz, Horrocks, or Gozani. Claim 3 also stands rejected under 35 U.S.C. § 103(a) as unpatentable over any of Cole, Schultz, or Horrocks in view of either Vourvopoulos or Gozani.

The Invention

The invention is directed to a method for qualitatively and quantitatively characterizing radionuclides in a sample comprising multiple nuclides. The method is very sensitive, and can be used to identify a small quantity of nuclide in a mixture. In accordance with the invention, two gamma-rays are pre-selected for each nuclide. These two gamma-rays are selected from among the many such rays emitted by the nuclide. For many nuclides, many pairs of gamma-rays are selected, one pair for each nuclide. Then, these two rays are simultaneously detected with a multiple gamma-ray detector assembly. The rays are plotted on axes, and the intersection of two rays identifies a particular nuclide. The relative abundance of the nuclide is detected by the height (count) of the peak at the intersection position.

Claims 4 and 5 have been entered in lieu of claims 1-3. Claim 4 is directed to a method of highly sensitive, qualitative and quantitative analysis of radionuclides in a sample by multiple gamma-ray detection. A pair of gamma-rays emitted concurrently from each of the radionuclides in a sample comprising radionuclides is detected simultaneously with a multiple gamma-ray detector assembly consisting of a plurality of gamma-ray detectors to determine energies of each of the concurrent pairs of gamma-rays. A two-dimensional matrix is constructed by plotting the energy of one gamma-ray of the concurrent pair of gamma-rays on one of the two axes and the energy of the other gamma-ray on the other axis and making a peak for each radionuclide on the axis vertical to the two axes by plotting the count of each gamma-ray at each position plotted on the matrix. Each radionuclide is specified from the position of the peak on the matrix by referring to known data of gamma-rays emitted from each radionuclide,

and the peak for each radionuclide is compared with a standard radiation source having known energy and intensity to measure the content of each radionuclide in the sample. In the method of claim 5, the radionuclides are radioactivated with neutrons or gamma-rays.

Remarks

Applicants respectfully traverse the rejections. The claimed invention is enabled, and the necessary information is present in the specification. Whereas the Office Action asserts that necessary algorithms, formulae, and the like are necessary to practice the invention, the claimed invention is not directed to any such features. Rather, the measurements of gamma-ray energies, plotting thereof, and comparison to a standard are methods known to the skilled practitioner. Further, as described more fully below, it is not necessary to monitor each isotope in accordance with the method of the invention, so the alleged failure to describe how each of the elements was identified is not a failure of enablement. Because the skilled practitioner knows how to determine an appropriate energy level for bombardment radiation, the disclosure is sufficient and enabling.

The best mode contemplated by the inventors of making and using the invention is disclosed. As set forth above, the algorithms, formulae, and the like are not features of the invention, and a skilled practitioner knows how to do the manipulations required to practice the claimed invention.

The claims particularly point out and distinctly claim the subject matter applicants regard as the invention. As described in the specification and further described below, all gamma-rays are not emitted at the same time, and the skilled practitioner recognizes, in view of the description in the specification, that gamma-ray detectors used in the invention select only simultaneous counting events, so the skilled practitioner recognizes that a pair of gamma-rays detected simultaneously are those simultaneously emitted from the nuclide.

Further, Applicants respectfully submit that the invention is not suggested by the cited documents, whether considered alone or in the proposed combinations. Neither the cited documents nor the proposed combinations suggest the claimed invention.

In particular, Applicants respectfully traverse the rejections as set forth below.

35 U.S.C. § 112, First Paragraph (Enablement)

The claims stand rejected as enabled only for measurement of a single nuclide, and the cited documents are said to disclose that different nuclides are likely to emit gamma-rays at the same or very similar energies. Further, algorithms and other features said to be necessary to practice the invention are said not to be disclosed. In particular, the quantification at page 13 of the specification is said not to be adequately described because each element has plural isotopes.

Applicants respectfully traverse this rejection. It is common technical knowledge that emission of gamma-rays from each of a plurality of radionuclides occurs not simultaneously, but

with a certain time interval. Therefore, in the present invention, those skilled in the art would readily know that all gamma-rays are not detected simultaneously by plural gamma-ray detectors, and that gamma-rays are detected with a certain intervening time interval.

In the present invention, as described in page 11, lines 20-22 of the specification, gamma-ray detectors choose only simultaneous counting events. Specifically, it is clear that gamma-rays simultaneously detected by the gamma-ray detectors are those simultaneously emitted from a given nuclide.

Additionally, it is well known that the energy of gamma-rays emitted from a nuclide will be different from the energy of gamma-rays emitted from a different nuclide. A number of studies have been carried out to determine the energies of gamma-rays emitted by a selected nuclide, and a number of publications containing such energy information are readily available. As an example of such information available to the skilled practitioner, Applicants respectfully submit a copy of selected pages of "Richard B. Firestone, TABLE OF ISOTOPES, EIGHTH EDITION, Volume I: A=1-150, JOHN WILEY & SONS, INC., 1996, page 1153 and 1285." These pages illustrate graphically various gamma-ray energies emitted by two different moieties.

The Isotope data book contains information about gamma-ray energies emitted from isotopic ^{131}Ba and ^{139}Ba. This data book makes it clear that isotopic ^{131}Ba and ^{139}Ba have different patterns of gamma-rays, and it is common technical knowledge that different isotopes emit different energy patterns of gamma-rays. Therefore, those skilled in the art can realize

energy of gamma-rays emitted from each nuclide (even if the nuclide is an isotope) with reference to this and other such published data books.

Then, when a two-dimensional matrix is constructed by plotting the measured energies of the gamma-rays, the radionuclide in question can be specified from the position of the peak on the resulting matrix, because the peak of each nuclide appears at an individual position on the matrix. That position is related to the identity of the nuclide and the gamma-ray energies detected, and is known from charts such as those from the TABLE OF ISOTOPES. Subsequently, comparing the peak for each nuclide with a standard radiation source having known energy and intensity enables the skilled practitioner to determine the content of each nuclide in the sample.

As described in detail above, those skilled in the art can carry out the claimed invention with reference to the description of the present specification together with common technical knowledge. The gamma-ray measurements, plotting the results, and comparison to a standard all are activities well within the skill of the practitioner. Therefore, Applicants respectfully submit that the present invention is described in a manner that those skilled in the art can carry out the invention.

The Office Action also asserts that various algorithms, formulae, and the like are not disclosed. However, the claimed invention does not include any feature related to computer processing. Rather, the skilled practitioner recognizes that the present invention is carried out without using any algorithms, formulae, or computer programs that are not already within the

skill of the practitioner. The skilled practitioner can, with the information provided in the specification, make and use the invention without difficulty.

The Office Action asserts that the quantification of 49 elements at page 13 is not adequately described because each element has plural isotopes. However, Applicants respectfully submit that it is within the technical knowledge of the skilled practitioner that gamma-rays emitted from isotopes have different energy patterns. For example, it is shown in "Table of Isotopes, EIGHTH EDITION, Volume I: A=1-150" that isotopic ^{131}Ba and ^{139}Ba have different patterns of gamma-rays. Therefore, even if a sample contains isotopic nuclides, those skilled in the art can refer to such published data books and, with the guidance provided by the specification, carry out the present invention.

Applicants respectfully submit that the cited documents also disclose such information, making it readily available to the skilled practitioner. For example, Cole, United States Patent Number 5,378,895, discloses a significant amount of information for the system disclosed therein. Applicants respectfully submit that such information is freely available to the skilled practitioner.

The Office Action further notes that the 23 elements determined at page 14, line 2 *et seq* also have plural isotopes, and so the invention is said not to be adequately disclosed. However, as is clearly set forth in the specification, this data relates to the prior art method, and so is not an example of the present invention.

The Office Action asserts that the specification does not disclose the energy level required to bombard the samples under consideration. However, it is within common technical knowledge in the art that any elements can be radioactivated by using thermal neutrons having an energy level of about 30 MeV. This is apparent from the fact that Instrumental Neutron Activation Analysis (INAA) is widely used. INAA is an analysis wherein a sample is fed to the core of atomic reactor and radioactivated by thermal neutrons. The details of INAA are described, for example, in "D. DeSoete et al., NEUTRON ACTIVATION ANALYSIS (New York, Wiley-Interscience, 1972)."

Therefore, for this and the other reasons set forth above, Applicants respectfully traverse this rejection.

35 U.S.C. § 112, First Paragraph (Best Mode)

The Office Action asserts that the specification fails to disclose the best mode contemplated by the inventors at the time the application was filed because the specification does not disclose algorithms and the like necessary to carry out the characterization of the 49 elements of Example 1.

Applicants respectfully traverse this rejection. As set forth above, the skilled practitioner recognizes that the present invention is carried out without using any algorithms, formulae, or computer programs that are not already within the skill of the practitioner. In Example 1, the specification clearly discloses the identification of 49 elements specifically listed at page 13, line

22 to page 14, line 1 of the specification that Applicants believe to be the best mode of the present invention. According to the claimed invention, these 49 elements can be identified by using a two-dimensional matrix.

Importantly, the method by which the 49 elements were identified also is clearly disclosed. The samples were irradiated, and the gamma-rays emitted by the sample were measured with the multiple gamma-ray detectors for about 4 days. Measurement began immediately after irradiation, and the two-dimensional matrix described in the specification was created. There is no need for further calculations or correlations after comparison to a standard.

Although the Office Action objects that necessary algorithms, formulae, or computer programs are not specified in the present specification, the claimed invention does not comprise any feature related to these items. Rather, the present invention can be carried out without using any algorithm, formula, or computer program. Rather, only known techniques of irradiation, measurement, plotting, and comparing to a standard, i.e., common technical knowledge, are used in accordance with the method disclosed in the specification.

Therefore, Applicants respectfully submit that the present specification meets the best mode requirements. Applicants respectfully traverse this rejection.

35 U.S.C. § 112, Second Paragraph

The claims stand rejected for failing to particularly point out and distinctly claim the subject matter Applicants regard as the invention. Applicants respectfully traverse this rejection.

The pending claims 4 and 5 distinctly claim the method of the invention. The assertion in the Office Action relating to missing steps relating to algorithms and the like is discussed above; no steps are missing. For these reasons, Applicants respectfully traverse this rejection.

35 U.S.C. § 102(b)

All claims stood rejected under 35 U.S.C. § 102(b) as anticipated by Cole, Schultz, Horrocks, or Gozani. Applicants respectfully traverse these rejections.

Cole discloses a system of multiple detectors for identification of specific isotopes in a high gamma-ray field, and describes that, when fission occurs, two fragments (fission products) and several gamma-rays are emitted (column 2, lines 17-38). However, as shown in Fig. 4A and Fig. 4B, Cole relates to one-dimensional spectrum plotting energy on horizontal axis and its count (intensity) on vertical axis. Further, Cole does not describe or suggest the two-dimensional matrix of gamma-ray energy used in the present invention. Therefore, Applicants respectfully submit that the claimed invention is not anticipated by Cole.

Schultz discloses a method for detecting explosive material which comprises the step of employing pulsed thermal neutron interrogation to form a nitrogen density image and an oxygen density image (column 2, lines 33-44). Schultz also neither describes nor suggests the two-dimensional matrix of gamma-ray energy of the present invention. Therefore, Applicants respectfully submit that Schultz does not anticipate the claimed invention.

Horrocks discloses a method of determining the radioactive source strength of a sample of a radionuclide which emits two coincidental quanta of radiation. However, as shown in Figures 1-3, the disclosure of Horrocks, like the disclosures of Cole and Schultz, relates to one-dimensional spectrum plotting energy on horizontal axis and its count (intensity) on vertical axis. Horrocks does not describe or suggest the two-dimensional matrix of gamma-ray energy, and so cannot anticipate the claimed invention.

Gozani discloses a method and an apparatus of detecting contraband within an object. Gozani's method comprises irradiating the object with beam of fast neutrons, measuring the emitted gamma-ray spectrum using a multiplicity of gamma-ray detectors, and constructing from the gamma-ray information three-dimensional images of the atomic nuclei spatial and density distributions (for example, claims 1 and 12). The invention of Gozani does not relate to a two-dimensional matrix of gamma-ray energy of the present invention. Therefore, Applicants respectfully submit that Gozani does not anticipate the claimed invention.

35 U.S.C. § 103(a)

Claim 3 stood rejected as obvious over any of Cole, Schultz, or Horrocks in view of either Vourvopoulos or Gozani. Applicants respectfully traverse this rejection.

As stated above, there is no description or suggestion relating to a two-dimensional matrix of gamma-ray energy in Cole, Schultz, Horrocks, or Gozani. Further, Vourvopoulous neither suggests nor describes a two-dimensional matrix of gamma-ray energy. Therefore, neither Gozani nor Vourvopoulous can provide that which is lacking from the primary references, i.e., Cole, Schultz, and Horrocks.

Therefore, Applicants respectfully traverse this rejection.

Conclusion

Applicants respectfully submit that the application is in condition for allowance. Each of the formal rejections and of the rejections on the merits has been traversed. The claims particularly point out and distinctly claim the subject matter Applicants regard as the invention, are enabled, meet the written description requirements. The best mode known to the inventors at the time the application was filed is disclosed, and the claims are allowable on the merits. Favorable action is solicited.

Respectfully submitted,

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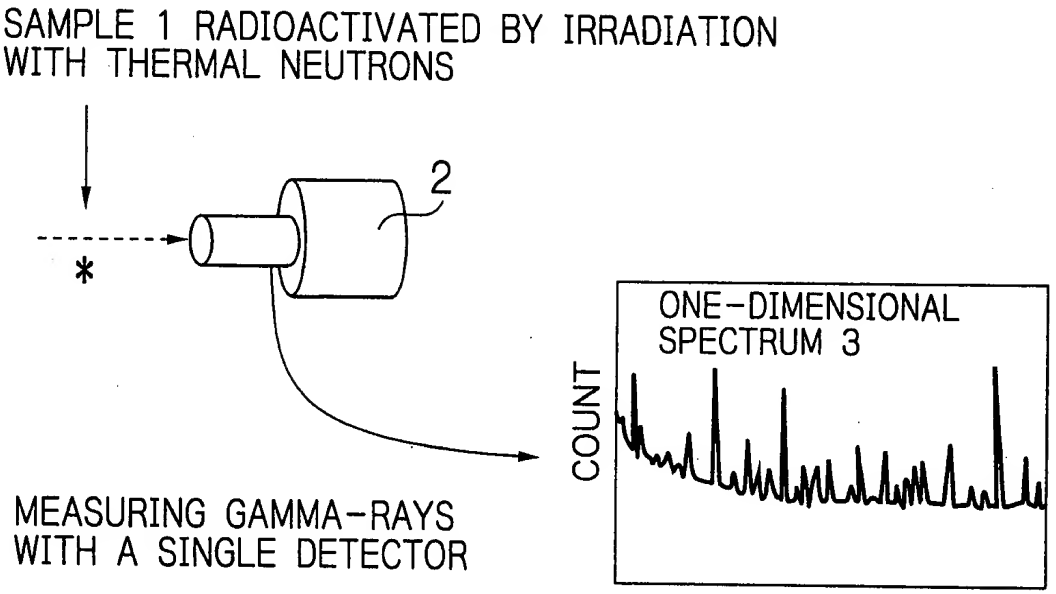
Fig. 1



PRIOR ART